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Streamflow Statistics for the Dennys River at Dennysville, Maine, 1955-2004

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U.S. Department of the Interior
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U.S. Department of the Interior
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U.S. Geological Survey
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CONTENTS

Figures

Tables

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Multiply	By	To obtain
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C = (°F-32)/1.8$$

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88) unless otherwise noted.

Streamflow Statistics for the Dennys River at Dennysville, Maine, 1955-2004

by Robert W. Dudley

Abstract

Long-term streamflow data in the Dennys River Basin have been collected at the U.S. Geological Survey (USGS) streamflow-gaging station number 01021200 on the mainstem of the Dennys River at Dennysville from October 1, 1955 through September 30, 1998, and from June 1, 2001 through the present (2005). Streamflow statistics of flow duration and annual, monthly, maximum, and minimum streamflows for the Dennys River were computed to help characterize the hydrology of the Dennys River for use in water management plans.

Streamflow in the Dennys River is regulated by Meddybemps Lake Dam, 14 miles upstream from the USGS station at Dennysville. From 1947 to 1973, outflows from Meddybemps Lake Dam were controlled for the purpose of hydro-electric power generation. The regulation of outflows from Meddybemps Lake to the Dennys River changed with the transfer of ownership of the Meddybemps Lake Dam to the Maine Atlantic Salmon Commission (ASC) in 1973. The ASC regulates outflow from Meddybemps Lake to provide habitat for resident and migratory life stages of Atlantic salmon, particularly during low-streamflow periods. Streamflow data from 1955-1972 and 1973-2004 represent different hydrologic conditions in the river, particularly during summer months. Streamflow statistics for the Dennys River were computed for the entire period of record, 1955 to 2004, and because of the change in streamflow regulation at Meddybemps Lake Dam by the ASC in 1973, two other time periods were analyzed: 1955 to 1972, and 1973 to 2004.

Introduction

The Dennys River is an important habitat resource for wild Atlantic Salmon. Currently, the wild Atlantic salmon populations are protected under the United States Endangered Species Act and are the subject of a comprehensive recovery program. In 1997, the State of Maine developed a conservation plan for Atlantic salmon in seven rivers in Maine (Maine Atlantic Salmon Task Force, 1997). As part of its implementation, the plan called for the development of water management plans for each of the river basins.

Long-term streamflow data in the Dennys River Basin, collected at U.S. Geological Survey (USGS) streamflow-gaging station number 01021200 on the mainstem of the Dennys River at Dennysville, can be used to assist with the management of water-quantity and quality in the basin. The streamflow-gaging station has been in operation from October 1, 1955 through September 30, 1998, and from June 1, 2001 through the present (2005) (Stewart and others, 2005).

The USGS, in cooperation with the Maine Atlantic Salmon Commission (ASC), began a study in 2004 to characterize the quantity, variability, and timing of streamflow in the Dennys River. Characterizing these hydrologic conditions will lead to a better understanding of water quantity and quality in the basin that will subsequently support ongoing and future Atlantic salmon management.

Purpose and Scope

The purpose of this report is to provide streamflow statistics derived from historical streamflow records from the USGS streamflow-gaging station on the Dennys River at Dennysville, Maine. This report includes a brief overview of the Dennys River Basin, the streamflow data and analytical methods used, and streamflow statistics of flow duration and annual, monthly, maximum, and minimum streamflows. The streamflow statistics are computed for three time periods: 1955-1972, 1973-2004, and 1955-2004.

Description of the Study Area

The Dennys River Basin is in Washington County, eastern Maine, on the coast of the Atlantic Ocean (fig. 1). Draining an area of 132 square miles (mi^2), the mainstem of the Dennys River flows about 20 miles (mi) from Meddybemps Lake in the northwestern part of the basin to Cobscook Bay on the Atlantic Ocean in the southeastern part of the basin (Fontaine, 1982). The headwaters at Pleasant Lake have an approximate water-surface elevation of 230 feet (ft). The largest tributary to the Dennys River is Cathance Stream (drainage area 35.4 mi^2), which joins the Dennys River about 1

mi upstream from the mouth at Cobscook Bay (Fontaine, 1982). The USGS streamflow-gaging station on the mainstem of the Dennys River at Dennysville (01021200) gages runoff from a 92.9 mi^2 drainage area; of that, runoff from 44.7 mi^2 (48 percent) is controlled at the outlet of Meddybemps Lake.

The Dennys River Basin is characterized by low-relief rolling topography with little development. The basin lies in a hydrophysiographic region of broad lowlands that were inundated by the ocean during deglaciation approximately 12,000 years ago (Randall, 2000; Thompson and Borns, 1985). Consequently, most surficial geologic materials in the basin are glacial till. The remainder of the materials are composed of fine-grained glaciomarine deposits (typically silt, clay, and sand), ice-contact glaciofluvial deposits (typically sand and gravel), and eskers (typically gravel and sand) (Thompson and Borns, 1985).

Washington County, Maine, is sparsely populated. The county had its highest population (45,232) around the time of the 1900 census (University of Maine, 2004). Since that time, population has decreased 25 percent to a population in 2000 of 33,941 people (13.2 people per mi^2) (University of Maine, 2004; U.S. Census Bureau, 2002). The most densely populated municipality in the Dennys River Basin is Dennysville, near the mouth of the river, which in 2000 had a population of 319 people (21.6 people per mi^2) (U.S. Census Bureau, 2002). Forestry-related industry has caused most of the land-use changes that have taken place in Washington County during the 20th century. The county is thought to have been most deforested around 1880 with total forest cover of about 85 percent; forest cover has increased since then to about 90 percent in 1995 (Irland, 1998). The effects of reforestation on the timing and magnitude of streamflows for the basin are unknown.

The climate of the Dennys River Basin is temperate with mild summers and cold winters. The mean annual air temperature from 1971 to 2000 was about 44 °F, with mean monthly air temperatures ranging from about 20 °F in January to about 66 °F in July (National Oceanic and Atmospheric Administration, 2002). Mean annual precipitation during the same 30-year period was approximately 45 in. which was fairly evenly distributed throughout the year (National Oceanic and Atmospheric Administration, 2002). Mean annual evapotranspiration (loss of water to the atmosphere by evaporation from the soil and transpiration from plants) from 1951 to 1980 was about 18 in. (Randall, 1996). Measured mean annual runoff from 1955 to 2004 was about 28 in. (Stewart and others, 2005).

Streamflow in the Dennys River is regulated by Meddybemps Lake Dam, 14 miles upstream from the USGS gage at Dennysville. The usable capacity of Meddybemps Lake is estimated to be 1.507 billion ft^3 (Stewart and others, 2005). From 1947 to 1973, the dam was used for hydro-electric power generation (Beland and others, 1982). The regulation of outflows from Meddybemps Lake to the Dennys River changed with the transfer of ownership of the Meddybemps Lake Dam to the ASC in 1973. At present (2005), the ASC regulates outflow from Meddybemps Lake to maximize favorable habitat conditions for resident and migratory life stages of Atlantic salmon, particularly during low-streamflow periods. In general, usable storage in Meddybemps Lake is raised from April to June by capturing spring runoff, lowered from July to October to augment low streamflows, and held constant from November to March (Kleinschmidt Energy and Water Resource Consultants, 2002). There are no known consumptive uses of any waterbody in the Dennys River watershed (Arter, 2005).

Median monthly streamflows in the Dennys River, recorded by USGS streamflow-gaging station number 01021200 at Dennysville, show a seasonal distribution common in Maine (fig. 2). The largest streamflows in coastal Maine typically occur in the spring (March, April, and May) when rain falls on a dense (ripe) snowpack or on saturated soils. Streamflows then recede as snowmelt ends and evapotranspiration increases. The recession typically persists into late summer (August and September) because of high evapotranspiration. Streamflow in late summer is dominated by ground-water discharge and is frequently augmented by runoff from rainfall events. As evapotranspiration decreases in the fall (October and November), streamflow increases. Repeated rainfall events and the occasional contribution of tropical-system-related precipitation can result in high streamflows during the fall. Low streamflows can occur during the winter (December, January, and February) if precipitation and surface water is frozen for extended periods of time.

Streamflow Statistics for the Dennys River at Dennysville, Maine

All streamflow statistics for this report were derived from streamflow data at USGS station 01021200 on the Dennys River at Dennysville. Data were retrieved from the National Water Information System (NWIS) (U.S. Geological Survey, 1998) for the period of record from October 1, 1955 through September 30, 1998, and from June 1, 2001 through September 30, 2004.

Streamflow statistics for the Dennys River were computed for three time periods because of the change in streamflow regulation at Meddybemps Lake Dam when ownership transferred to the ASC in 1973: (1) the entire period of record from October 1, 1955 through September 30, 1998 and from June 1, 2001 through September 30, 2004 referred to as 1955-2004 for the remainder of this report; (2) the period of record from October 1, 1955 through December 31, 1972 referred to as 1955-1972; and (3) the period of record from January 1, 1973 through September 30, 1998 and from June 1, 2001 through September 30, 2004 referred to as 1973-2004 (fig. 2).

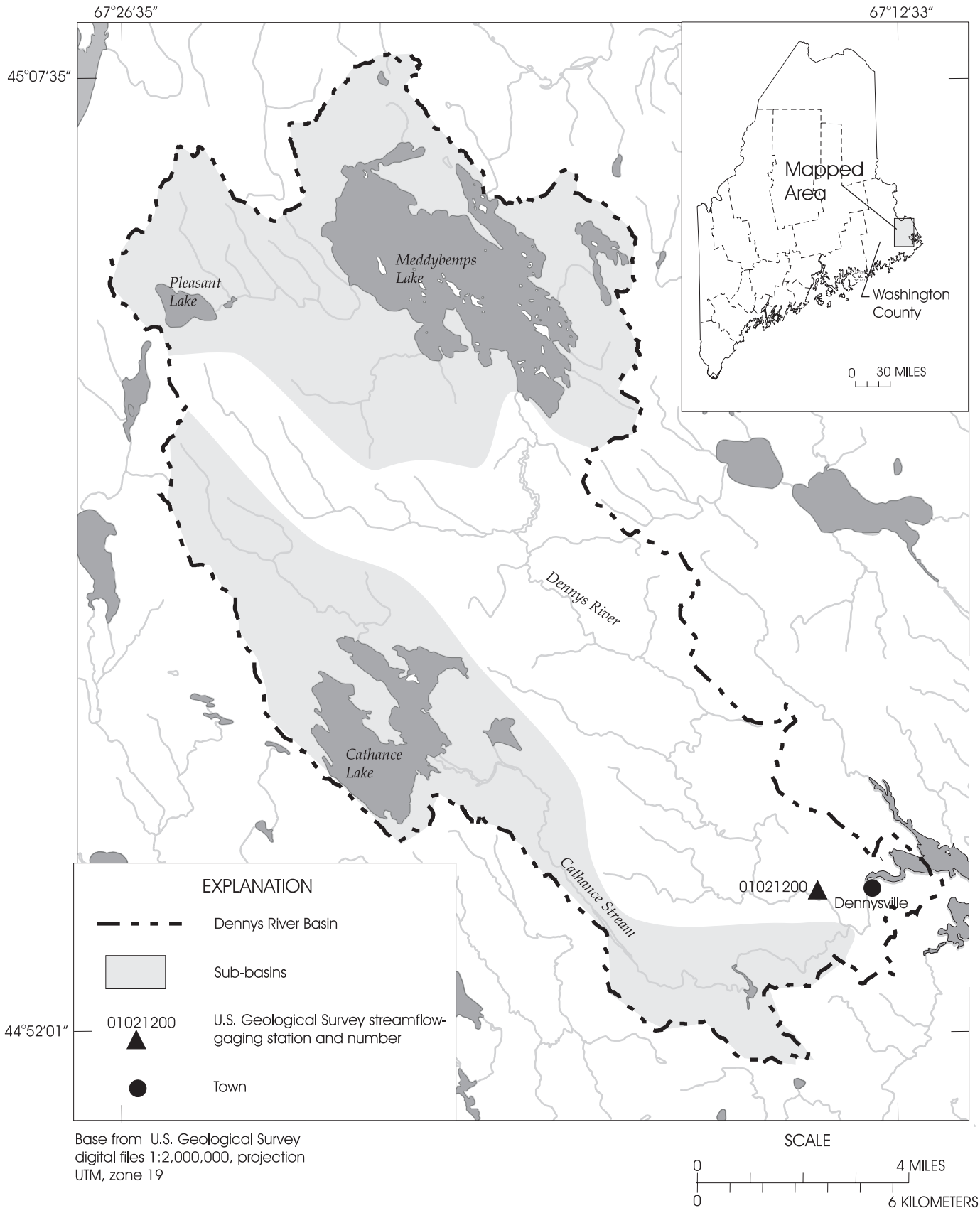

Figure 1. The Dennys River Basin and location of U.S. Geological Survey streamflow-gaging station number 01021200 at Dennysville, Maine.

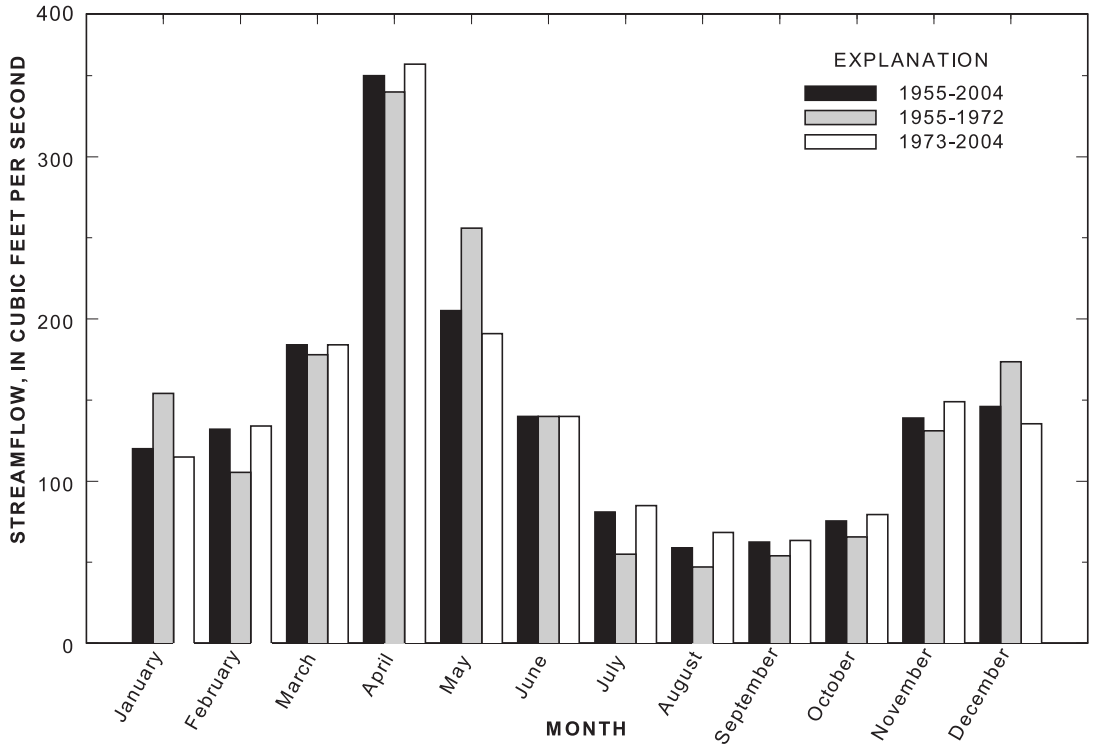

Figure 2. Median monthly streamflows for the Dennys River at Dennysville, Maine. (1955-2004 denotes the period of record from October 1, 1955 through September 30, 1998 and from June 1, 2001 through September 30, 2004; 1955-1972 denotes the period of record from October 1, 1955 through December 31, 1972; 1973-2004 denotes the period of record from January 1, 1973 through September 30, 1998 and from June 1, 2001 through September 30, 2004)

The total volume of streamflow gaged each year divided by the drainge-basin area provides a measure of annual runoff. Mean annual runoff in the basin was 28.2 in. for 1955-2004, 27.1 in. for 1955-1972, and 28.8 in. for 1973-2004. The non-parametric Mann-Kendall test was used to test for a temporal trend in annual runoff over the entire period of record (Helsel and Hirsch, 1992). There was no statistically significant (p-value < 0.01) trend in annual runoff from 1955 to 2004.

Median monthly and annual streamflows were computed for each of the three periods of record (table 1). Statistics were computed only for months and years with complete data. The computation of median monthly streamflows was a two-step process. First, the monthly median streamflow for each month for each year was computed from the daily mean streamflow data stored in NWIS. Second, the median monthly streamflow was computed as the median of all monthly medians over the periods of record analyzed. Median annual streamflows were computed in a similar manner. First, the annual median streamflow for each calendar year was computed on the basis of daily mean streamflow data from NWIS. Second, the median annual streamflow was computed as the median of all annual medians over the periods of record analyzed.

Mean monthly and annual streamflows also were computed for each of the three periods of record (table 1). Statistics were computed only for months and years with complete data. The computation of mean monthly and annual streamflows was done in a similar manner to the computation of median streamflows. The mean monthly values used in the computation are computed and published annually by the USGS in the water-resources data report series and stored in NWIS. Mean annual streamflows were computed as the mean of all annual means (calendar-year basis) over the periods of record analyzed.

Flow-duration statistics were computed for each month for each of the three periods of record analyzed (figs. 3-14). The flow-duration statistics were estimated by arranging all the daily mean streamflows for a given month and period of record in ranked order without regard to their temporal sequence of occurrence. Their frequencies of exceedance were then

Table 1. Median and mean monthly and annual streamflows for the Dennys River at Dennysville, Maine.

[All values are in cubic feet per second; 1955-2004 denotes the period of record from October 1, 1955 through September 30, 1998 and from June 1, 2001 through September 30, 2004; 1955-1972 denotes the period of record from October 1, 1955 through December 31, 1972; 1973-2004 denotes the period of record from January 1, 1973 through September 30, 1998 and from June 1, 2001 through September 30, 2004]

	Medians			Means		
Period	1955-2004	1955-1972	1973-2004	1955-2004	1955-1972	1973-2004
January	120	154	115	188	193	184
February	132	106	134	187	180	191
March	184	178	184	260	212	289
April	350	340	357	436	450	428
May	205	256	191	272	292	260
June	140	140	140	165	143	178
July	81.0	55.0	85.0	100	81.4	111
August	59.0	47.0	68.5	75.3	56.3	86.1
September	62.5	54.0	63.5	78.5	71.4	82.5
October	75.5	65.5	79.5	113	95	125
November	139	131	149	195	207	187
December	146	174	136	219	228	214
Annual	134	133	134	193	185	197

computed using the Weibull formula for computing plotting position (Helsel and Hirsch, 1992). Daily mean streamflows equaled or exceeded 1-, 10-, 25-, 50-, 75-, 90-, and 99-percent of the time are tabulated with the flow-duration curves (figs. 3-14). The flow-duration computed medians (50-percent exceedance) may differ slightly from the medians computed for Table 1 because of the difference in computational methods. The minimum and maximum daily mean streamflows for each month for each of the three periods of record are tabulated with the percent-exceedance data accompanying the flow-duration curves (figs. 3-14).

Acknowledgements

The author thanks the Maine Atlantic Salmon Commission for providing support for this study and the many USGS hydrologic technicians who have collected streamflow field data over nearly a century. Reviews by Gregory Stewart, Laura Flight, Elizabeth Ahearn, and Barbara Korzendorfer resulted in scientific and editorial improvements in this report.

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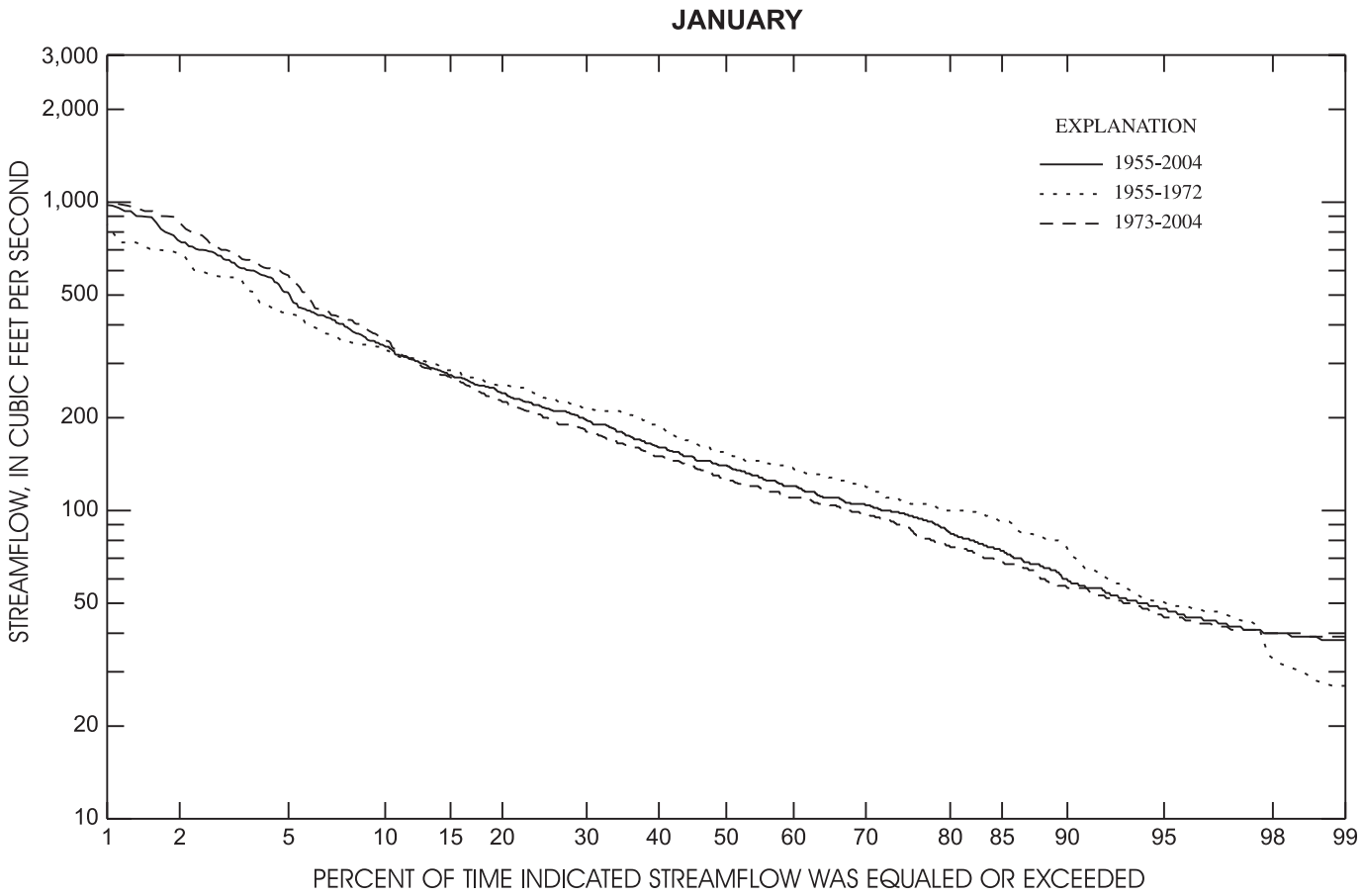
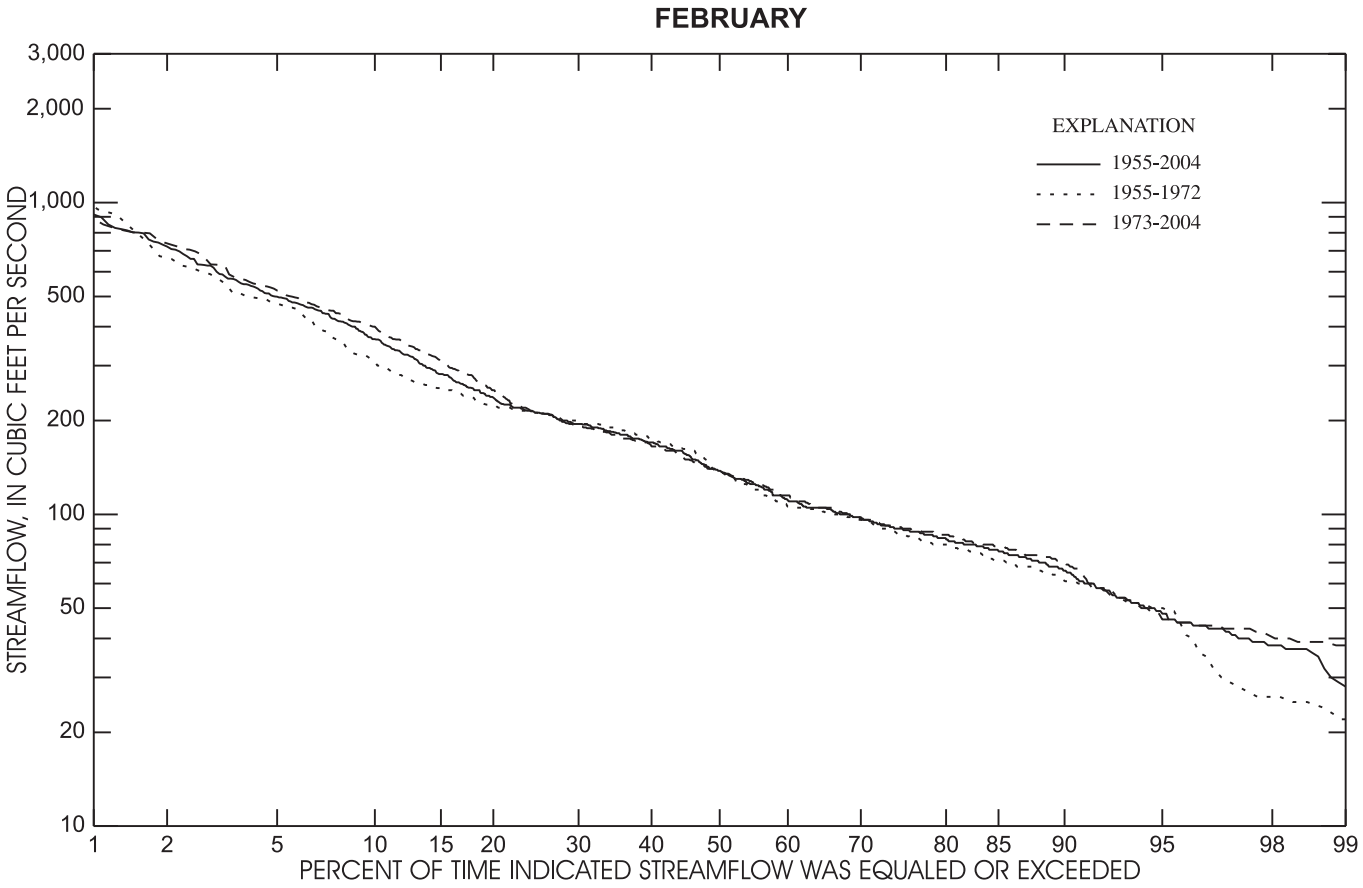
Figures 3 - 14



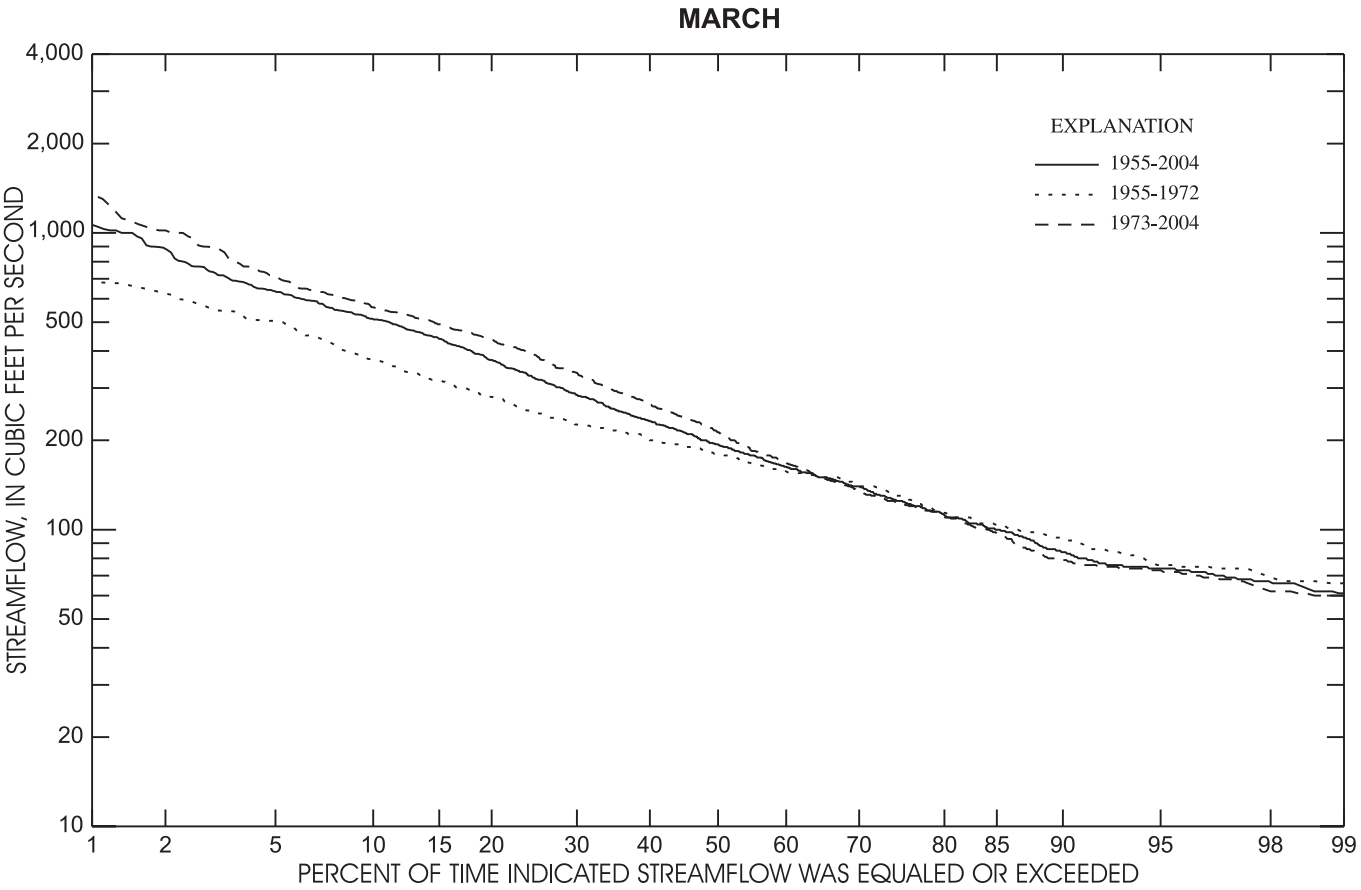
Percent of time indicated streamflow was equaled or exceeded and extremes	1955-2004		1955-1972		1973-2004	
	Streamflow	Year of extreme	Streamflow	Year of extreme	Streamflow	Year of extreme
Maximum	1,850	1979	1,320	1958	1,850	1979
1	979		851		1,000	
10	341		332		355	
25	214		230		200	
50	140		154		125	
75	97		106		88	
90	59		75		56	
99	38		27		39	
Minimum	20	1956	20	1956	37	1995

Figure 3. Flow-duration curves and statistics for January based on historical streamflow record of daily mean flows from October 1, 1955 through September 30,1998, and from June 1, 2001 through September 30, 2004, at U.S. Geological Survey streamflow-gaging station number 01021200, Dennys River at Dennysville, Maine.



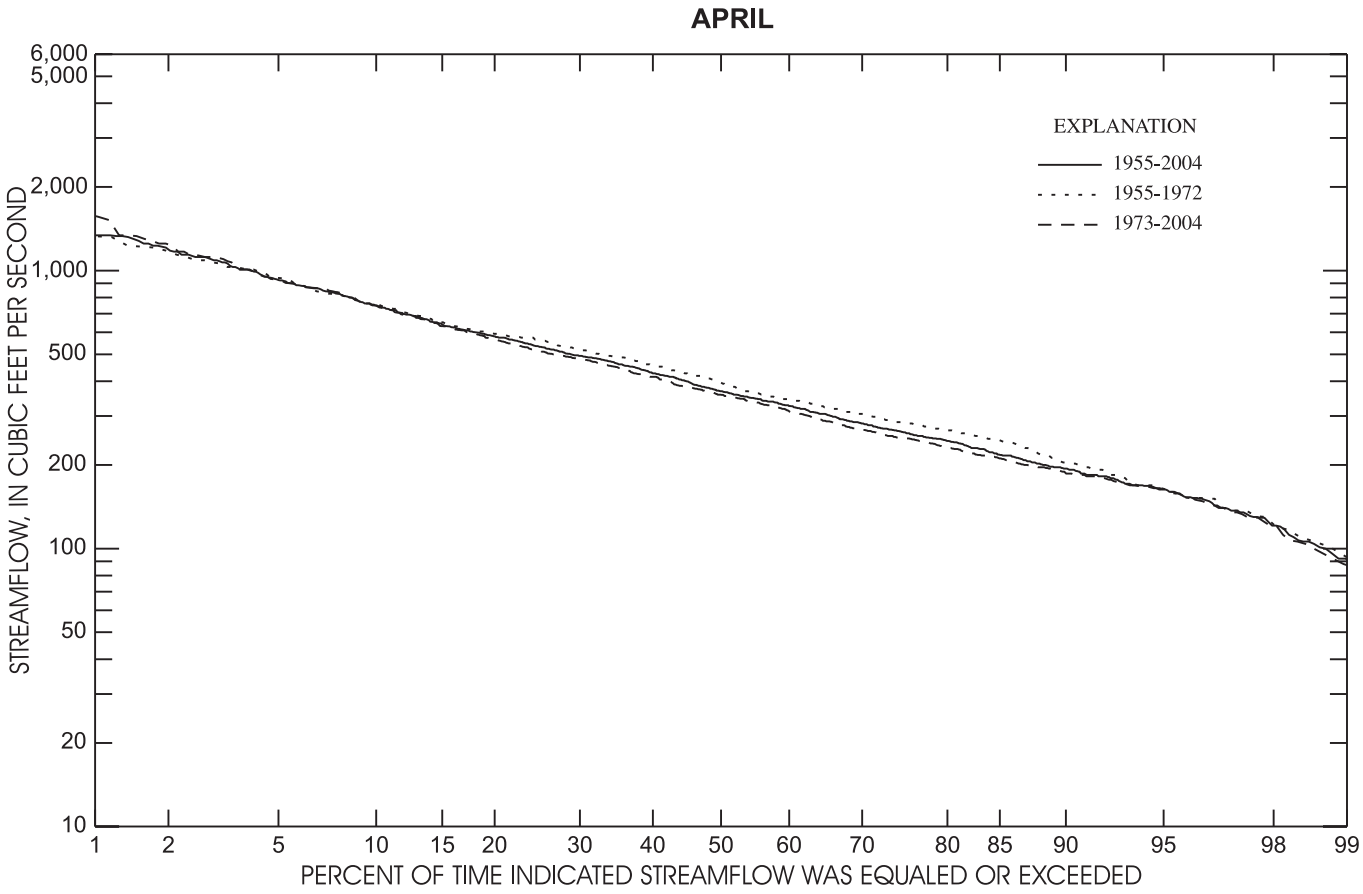
Percent of time indicated streamflow was equaled or exceeded and extremes	1955-2004		1955-1972		1973-2004	
	Streamflow	Year of extreme	Streamflow	Year of extreme	Streamflow	Year of extreme
Maximum	1,800	1970	1,800	1970	1,580	2002
1	916		979		888	
10	365		310		400	
25	212		211		212	
50	138		138		138	
75	90		86		91	
90	66		61		70	
99	28		22		38	
Minimum	20	1972	20	1972	37	1985

Figure 4. Flow-duration curves and statistics for February based on historical streamflow record of daily mean flows from October 1, 1955 through September 30,1998, and from June 1, 2001 through September 30, 2004, at U.S. Geological Survey streamflow-gaging station number 01021200, Dennys River at Dennysville, Maine.



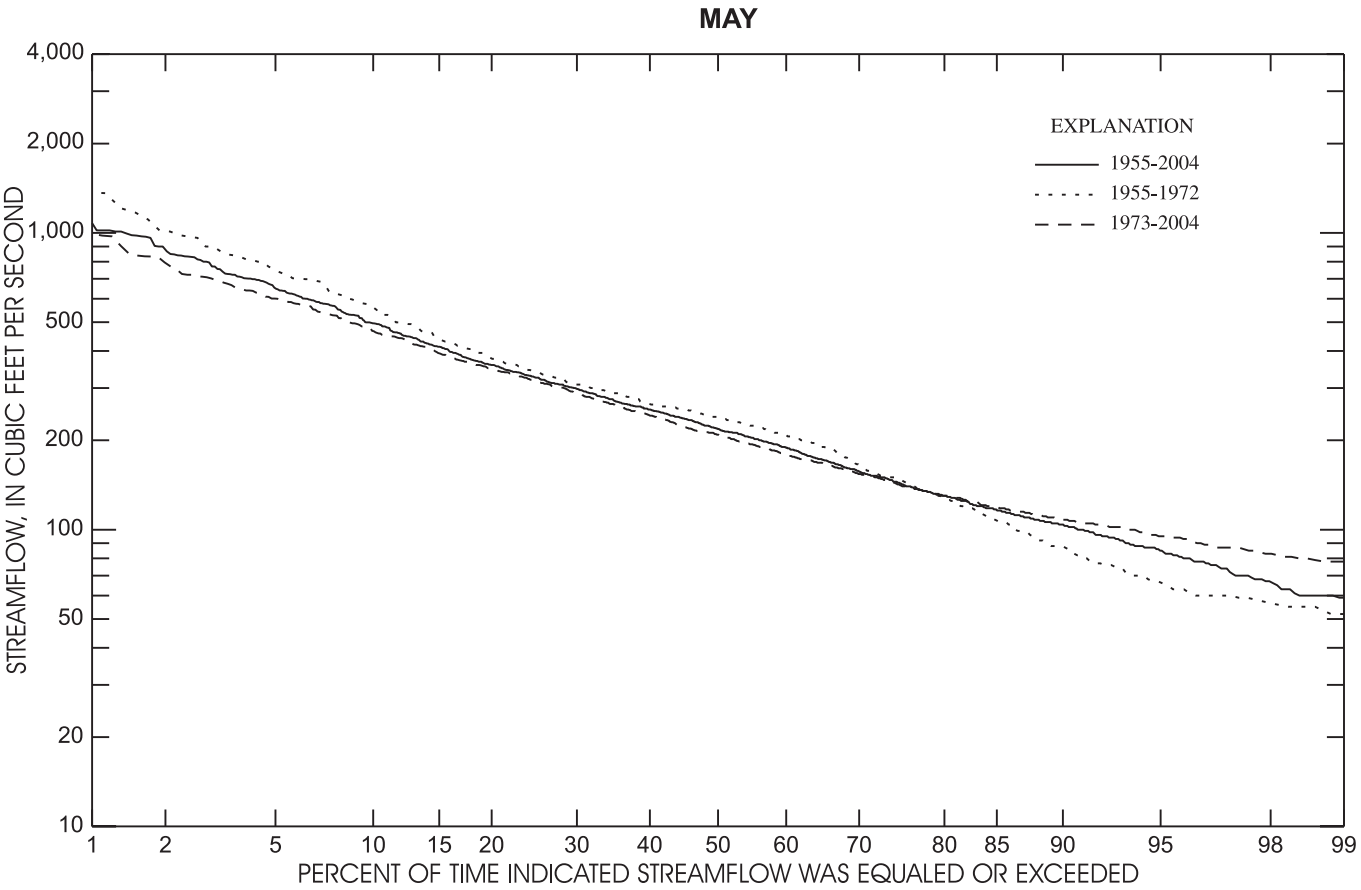
Percent of time indicated streamflow was equaled or exceeded and extremes	1955-2004		1955-1972		1973-2004	
	Streamflow	Year of extreme	Streamflow	Year of extreme	Streamflow	Year of extreme
Maximum	2,900	1998	805	1966	2,900	1998
1	1,060		683		1,350	
10	512		373		562	
25	322		248		386	
50	194		180		213	
75	125		130		123	
90	84		94		79	
99	61		66		60	
Minimum	44	2004	51	1962	44	2004

Figure 5. Flow-duration curves and statistics for March based on historical streamflow record of daily mean flows from October 1, 1955 through September 30,1998, and from June 1, 2001 through September 30, 2004, at U.S. Geological Survey streamflow-gaging station number 01021200, Dennys River at Dennysville, Maine.



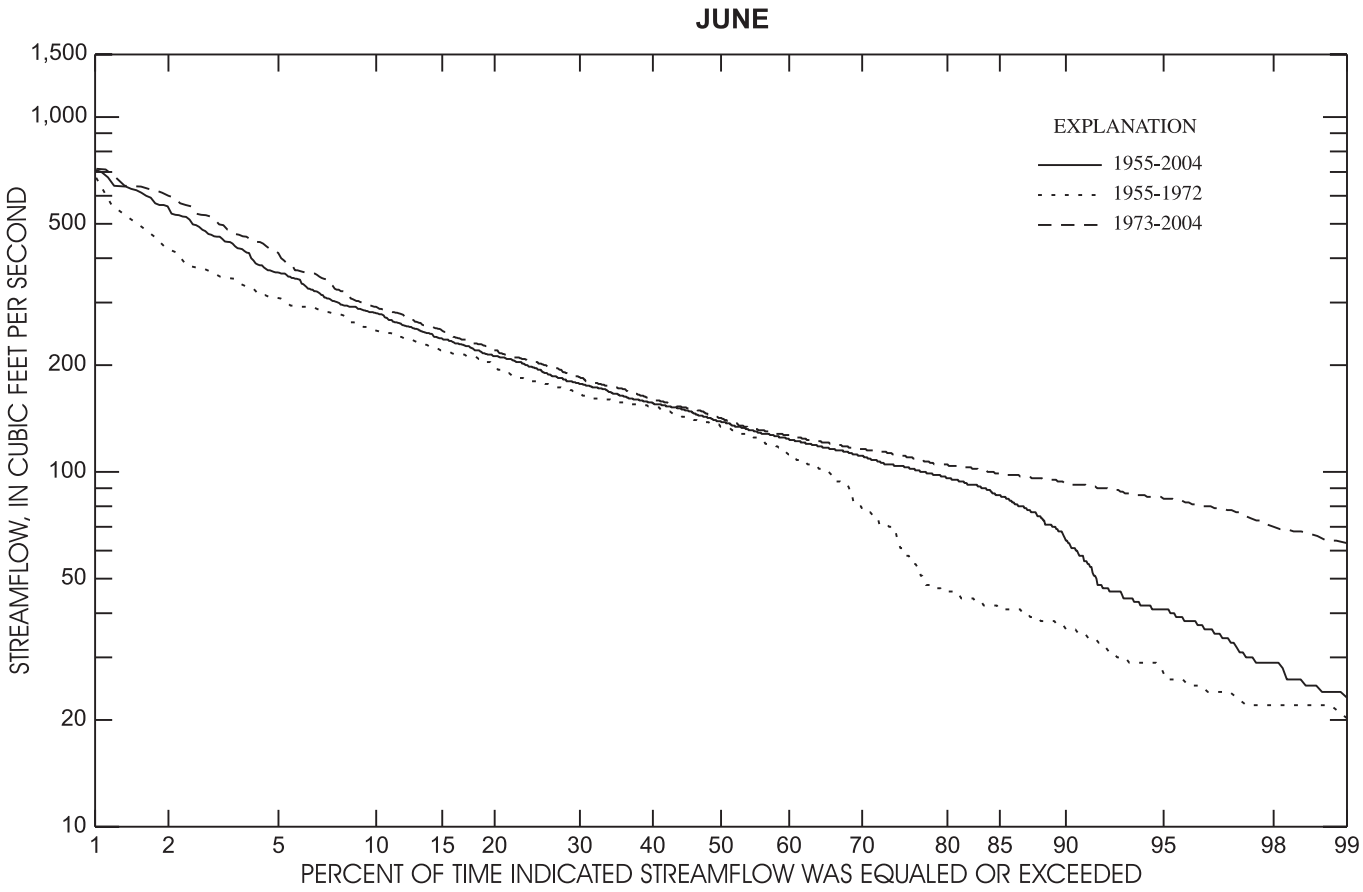
Percent of time indicated streamflow was equaled or exceeded and extremes	1955-2004		1955-1972		1973-2004	
	Streamflow	Year of extreme	Streamflow	Year of extreme	Streamflow	Year of extreme
Maximum	3,350	1973	2,320	1962	3,350	1973
1	1,340		1,330		1,570	
10	750		756		747	
25	532		563		515	
50	368		395		358	
75	263		285		250	
90	194		204		186	
99	91		93		87	
Minimum	77	1985	78	1965	77	1985

Figure 6. Flow-duration curves and statistics for April based on historical streamflow record of daily mean flows from October 1, 1955 through September 30,1998, and from June 1, 2001 through September 30, 2004, at U.S. Geological Survey streamflow-gaging station number 01021200, Dennys River at Dennysville, Maine.



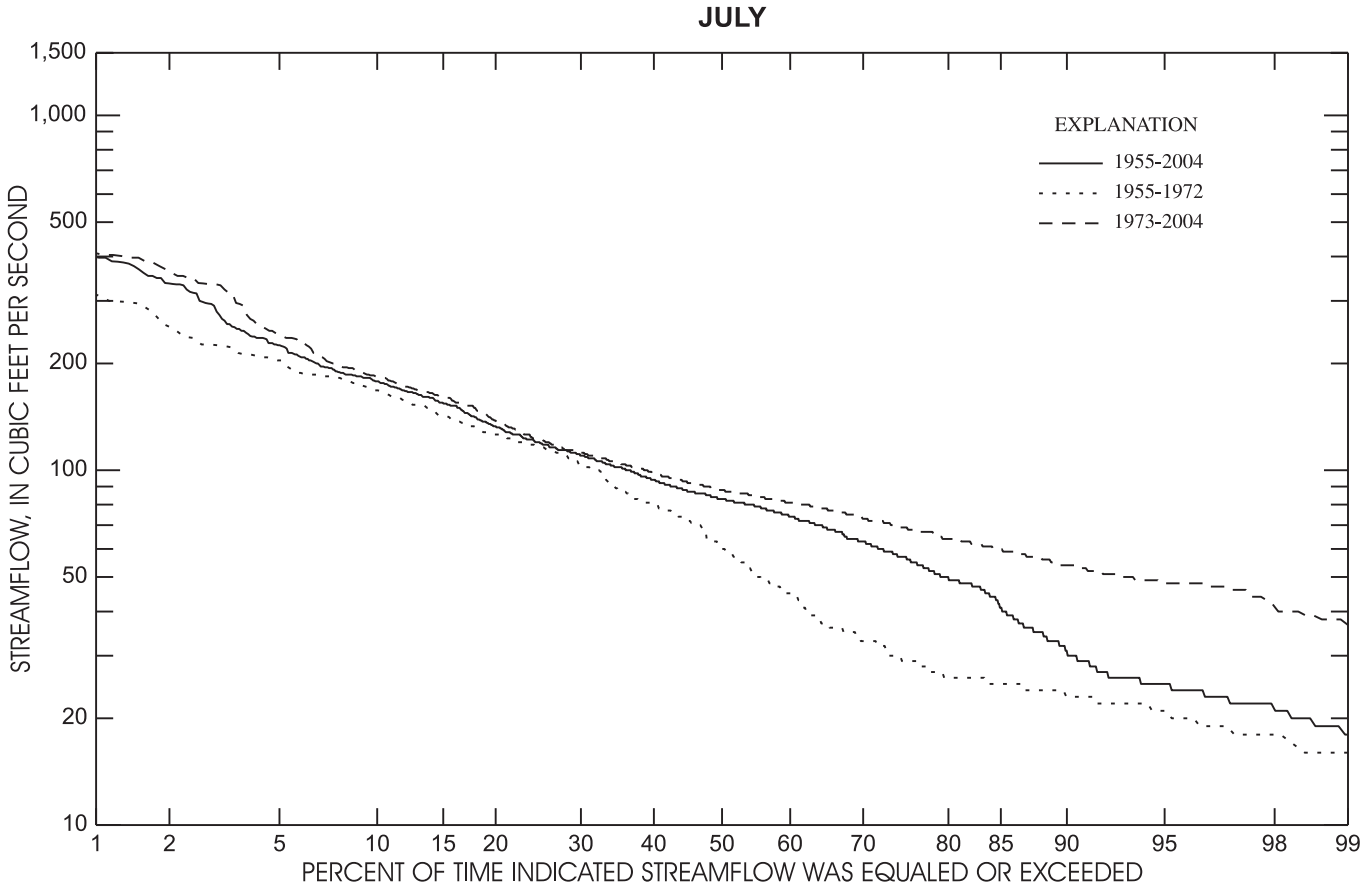
Percent of time indicated streamflow was equaled or exceeded and extremes	1955-2004		1955-1972		1973-2004	
	Streamflow	Year of extreme	Streamflow	Year of extreme	Streamflow	Year of extreme
Maximum	2,500	1961	2,500	1961	1,550	1973
1	1,090		1,370		995	
10	496		562		468	
25	325		340		317	
50	219		238		210	
75	145		147		144	
90	105		88		110	
99	59		52		78	
Minimum	43	1957	43	1957	58	1977

Figure 7. Flow-duration curves and statistics for May based on historical streamflow record of daily mean flows from October 1, 1955 through September 30,1998, and from June 1, 2001 through September 30, 2004, at U.S. Geological Survey streamflow-gaging station number 01021200, Dennys River at Dennysville, Maine.



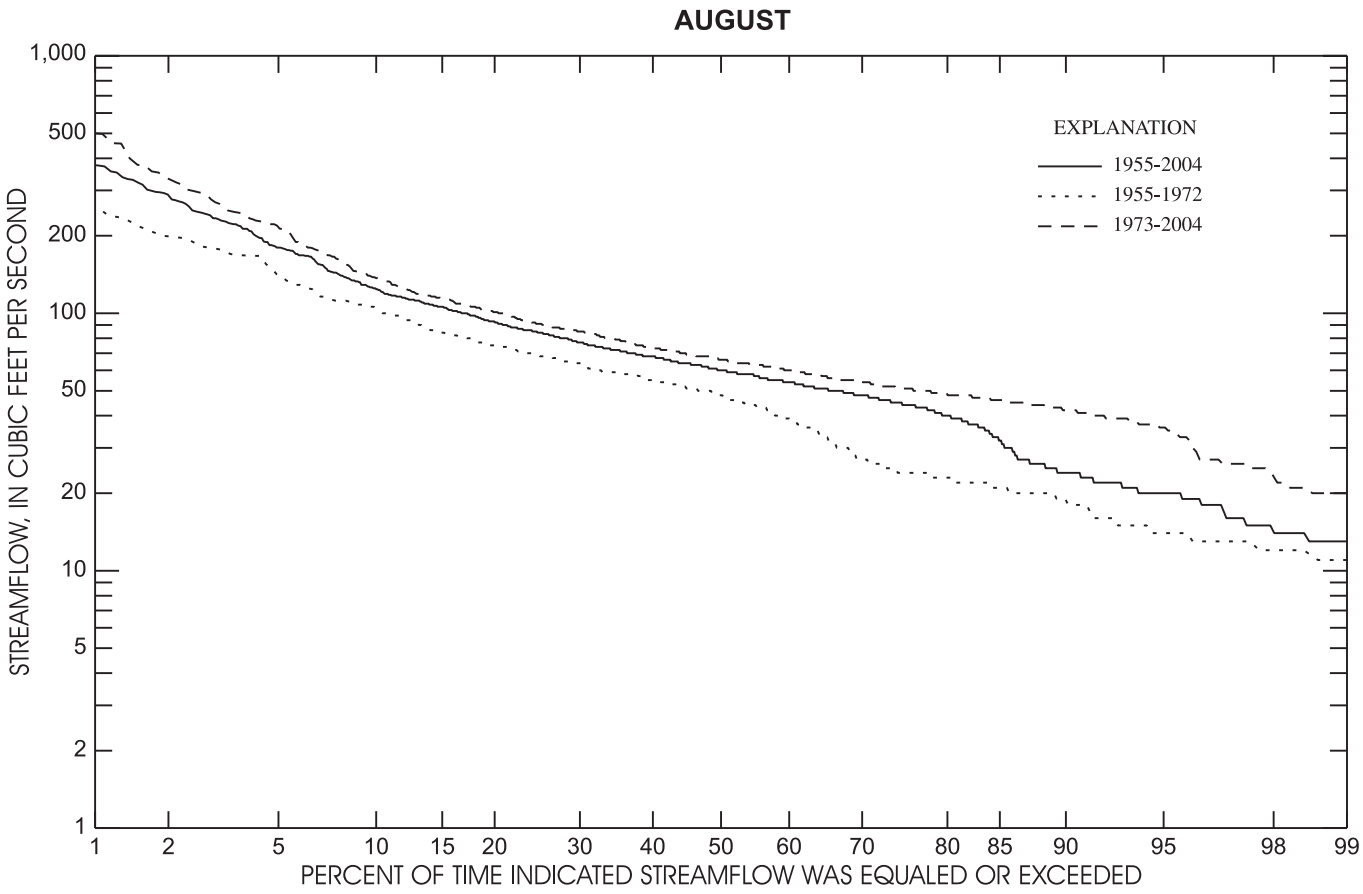
Percent of time indicated streamflow was equaled or exceeded and extremes	1955-2004		1955-1972		1973-2004	
	Streamflow	Year of extreme	Streamflow	Year of extreme	Streamflow	Year of extreme
Maximum	1,120	1959	1,120	1959	1,020	1979
1	710		685		715	
10	280		250		292	
25	194		179		202	
50	138		134		142	
75	104		61		111	
90	64		36		92	
99	23		20		63	
Minimum	18	1957	18	1957	52	2001

Figure 8. Flow-duration curves and statistics for June based on historical streamflow record of daily mean flows from October 1, 1955 through September 30,1998, and from June 1, 2001 through September 30, 2004, at U.S. Geological Survey streamflow-gaging station number 01021200, Dennys River at Dennysville, Maine.



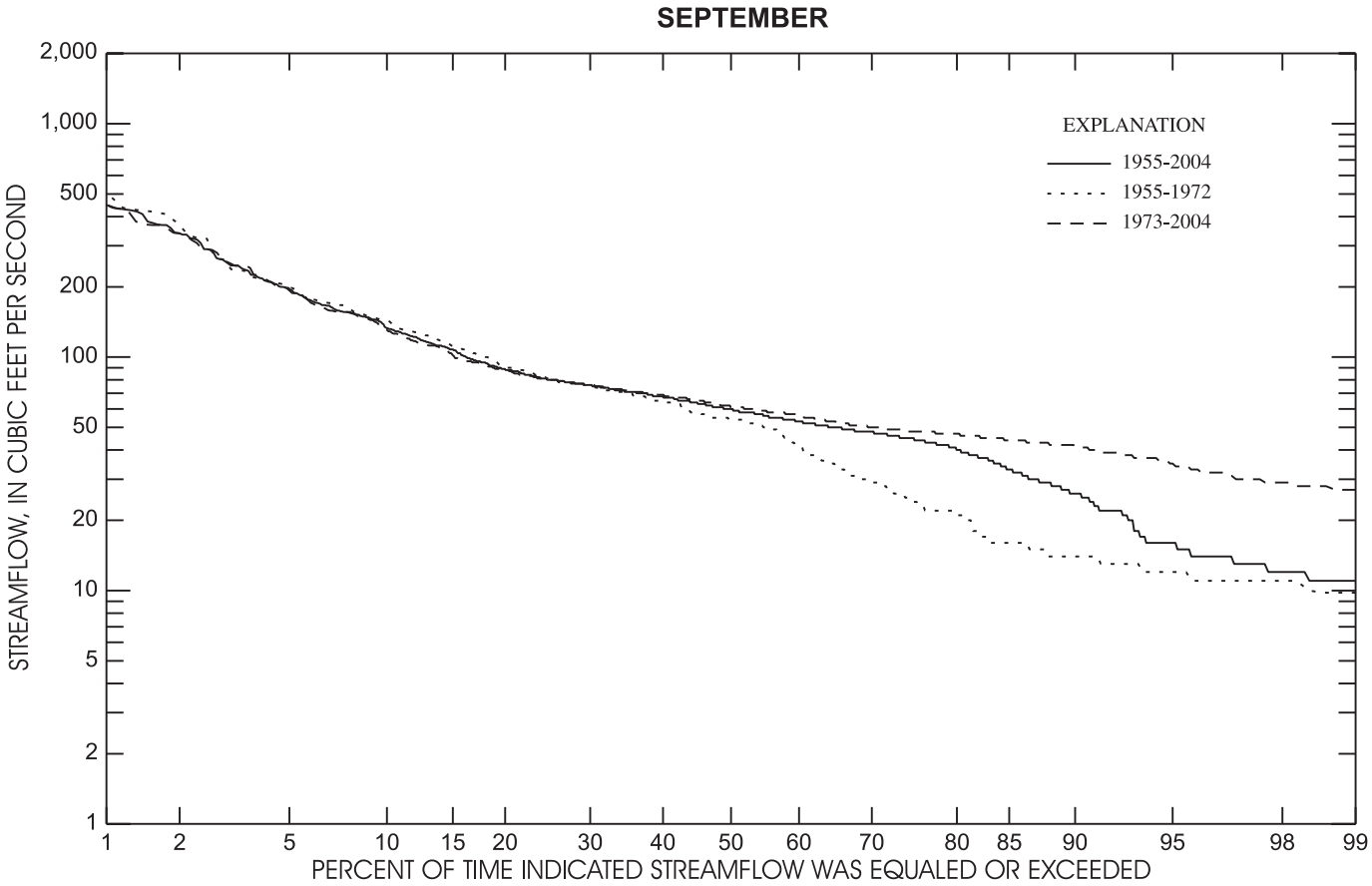
Percent of time indicated streamflow was equaled or exceeded and extremes	1955-2004		1955-1972		1973-2004	
	Streamflow	Year of extreme	Streamflow	Year of extreme	Streamflow	Year of extreme
Maximum	868	1996	617	1959	868	1996
1	399		313		409	
10	178		168		183	
25	119		116		122	
50	83		60		88	
75	57		29		69	
90	31		23		54	
99	18		16		37	
Minimum	15	1956	15	1956	25	1975

Figure 9. Flow-duration curves and statistics for July based on historical streamflow record of daily mean flows from October 1, 1955 through September 30,1998, and from June 1, 2001 through September 30, 2004, at U.S. Geological Survey streamflow-gaging station number 01021200, Dennys River at Dennysville, Maine.



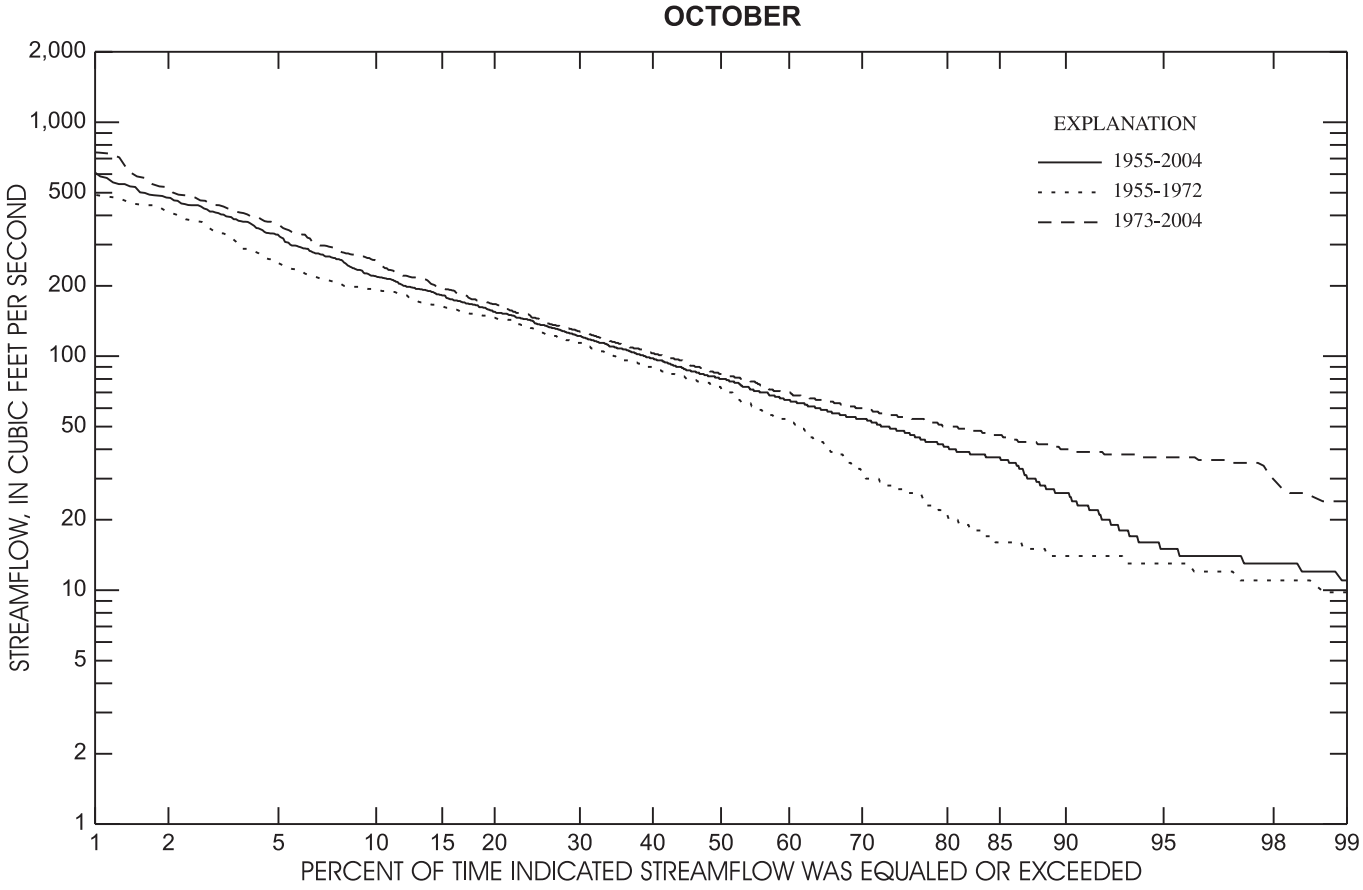
Percent of time indicated streamflow was equaled or exceeded and extremes	1955-2004		1955-1972		1973-2004	
	Streamflow	Year of extreme	Streamflow	Year of extreme	Streamflow	Year of extreme
Maximum	702	1981	372	1970	702	1981
1	376		263		500	
10	124		104		137	
25	84		68		91	
50	60		48		66	
75	44		24		51	
90	24		19		42	
99	13		11		20	
Minimum	9.4	1956	9.4	1956	18	1975

Figure 10. Flow-duration curves and statistics for August based on historical streamflow record of daily mean flows from October 1, 1955 through September 30,1998, and from June 1, 2001 through September 30, 2004, at U.S. Geological Survey streamflow-gaging station number 01021200, Dennys River at Dennysville, Maine.



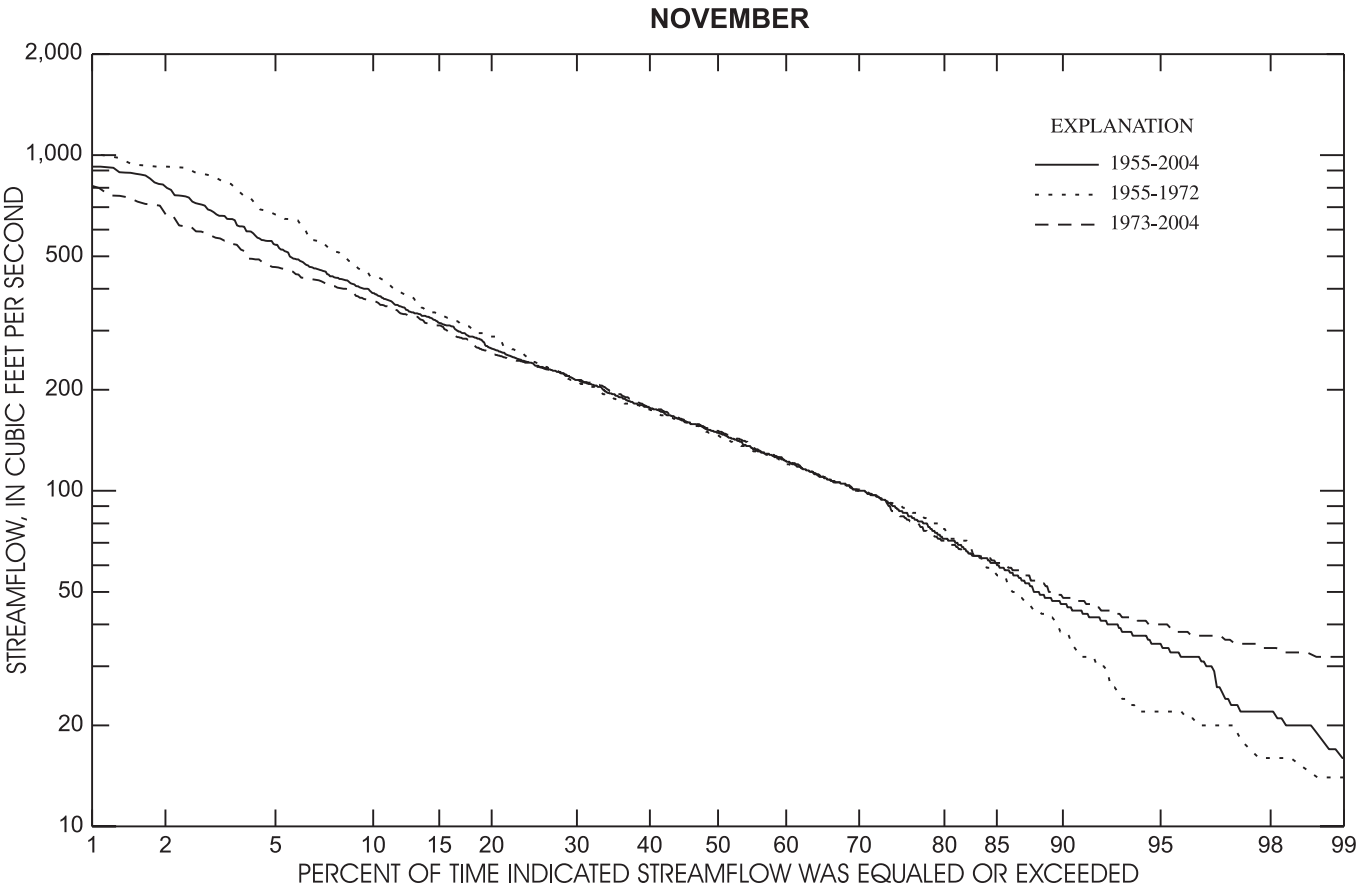
Percent of time indicated streamflow was equaled or exceeded and extremes	1955-2004		1955-1972		1973-2004	
	Streamflow	Year of extreme	Streamflow	Year of extreme	Streamflow	Year of extreme
Maximum	1,270	1981	642	1967	1,270	1981
1	448		508		450	
10	133		144		131	
25	80		80		80	
50	60		54		61	
75	45		24		48	
90	26		14		41	
99	11		10		27	
Minimum	8.6	1957	8.6	1957	25	1978

Figure 11. Flow-duration curves and statistics for September based on historical streamflow record of daily mean flows from October 1, 1955 through September 30,1998, and from June 1, 2001 through September 30, 2004, at U.S. Geological Survey streamflow-gaging station number 01021200, Dennys River at Dennysville, Maine.



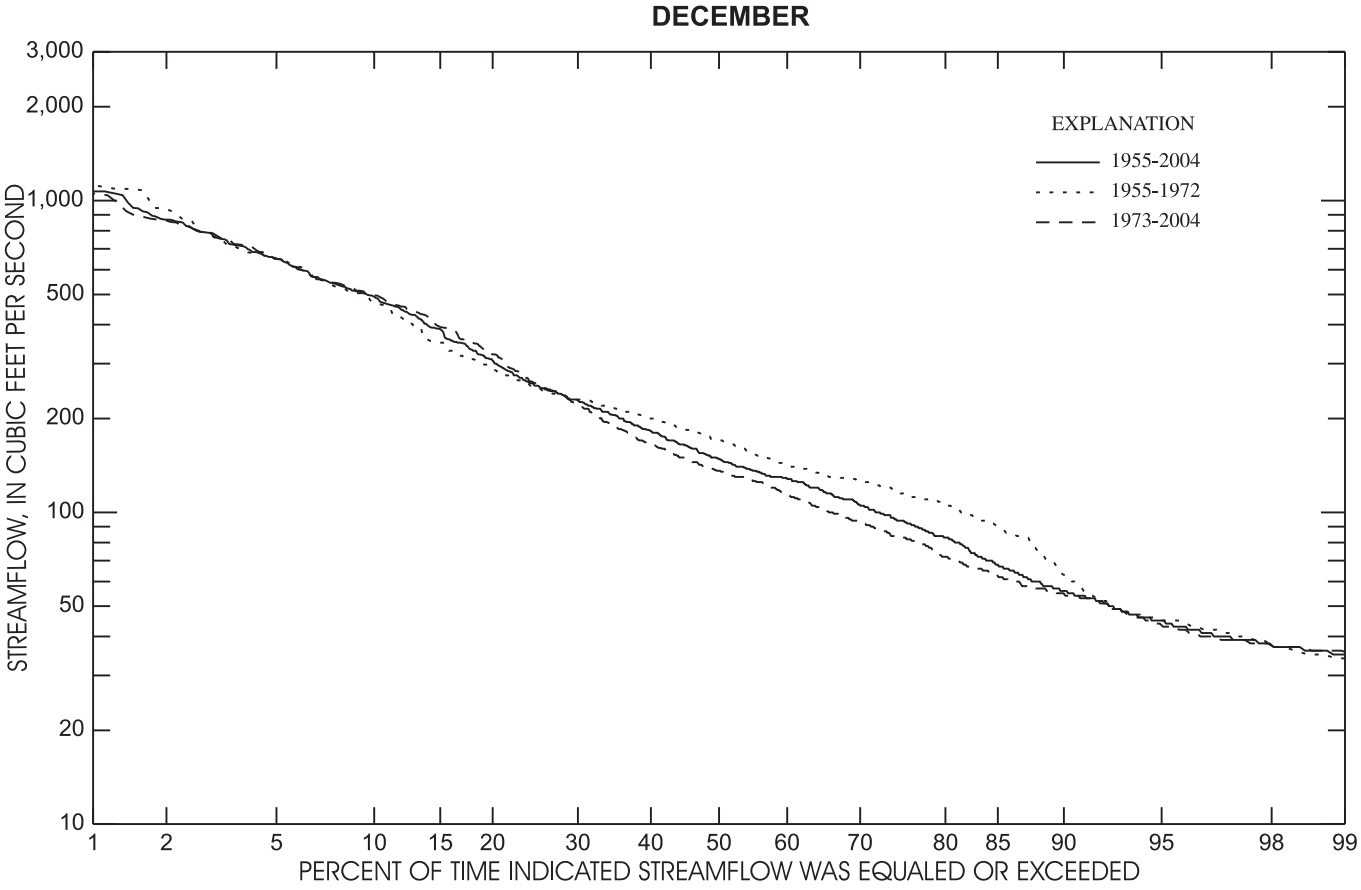
Percent of time indicated streamflow was equaled or exceeded and extremes	1955-2004		1955-1972		1973-2004	
	Streamflow	Year of extreme	Streamflow	Year of extreme	Streamflow	Year of extreme
Maximum	1,330	2003	1,100	1963	1,330	2003
1	610		490		743	
10	219		192		255	
25	137		128		144	
50	80		73		84	
75	48		27		55	
90	26		14		40	
99	11		10		24	
Minimum	8.7	1957	8.7	1957	20	1975

Figure 12. Flow-duration curves and statistics for October based on historical streamflow record of daily mean flows from October 1, 1955 through September 30,1998, and from June 1, 2001 through September 30, 2004, at U.S. Geological Survey streamflow-gaging station number 01021200, Dennys River at Dennysville, Maine.



Percent of time indicated streamflow was equaled or exceeded and extremes	1955-2004		1955-1972		1973-2004	
	Streamflow	Year of extreme	Streamflow	Year of extreme	Streamflow	Year of extreme
Maximum	1,290	1963	1,290	1963	1,130	1983
1	925		1,010		810	
10	388		436		368	
25	236		241		234	
50	149		146		151	
75	87		90		84	
90	46		38		48	
99	16		14		32	
Minimum	13	1965	13	1965	16	2001

Figure 13. Flow-duration curves and statistics for November based on historical streamflow record of daily mean flows from October 1, 1955 through September 30,1998, and from June 1, 2001 through September 30, 2004, at U.S. Geological Survey streamflow-gaging station number 01021200, Dennys River at Dennysville, Maine.



Percent of time indicated streamflow was equaled or exceeded and extremes	1955-2004		1955-1972		1973-2004	
	Streamflow	Year of extreme	Streamflow	Year of extreme	Streamflow	Year of extreme
Maximum	1,680	1987	1,560	1969	1,680	1987
1	1,070		1,130		1,050	
10	492		469		496	
25	255		251		256	
50	148		170		136	
75	94		115		84	
90	56		63		55	
99	35		34		36	
Minimum	30	1971	30	1971	32	2001

Figure 14. Flow-duration curves and statistics for December based on historical streamflow record of daily mean flows from October 1, 1955 through September 30,1998, and from June 1, 2001 through September 30, 2004, at U.S. Geological Survey streamflow-gaging station number 01021200, Dennys River at Dennysville, Maine.

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